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# SCIENCE

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CONTENTS



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## THE RELATION OF PHYSIOLOGY TO OTHER SCIENCES[1]

OUR subject of physiology has developed so rapidly during the last few decades, has taken so definite a place among the sciences and has such intimate relations with other subjects, that its position as a branch of natural knowledge is one of some general interest.

Physiology has a threefold appeal—as the master-key of medicine its practical value is self-evident, as a science it has now a distinctive position, while its relations to philosophy command the attention of all thoughtful men. We will consider it, for convenience sake, from these three standpoints.

From the earliest times, physiological knowledge, whether known by that name or not, has had the closest association with medicine. It would indeed be difficult to imagine any great advance in the one that was not immediately reflected in the other. Their methods, though necessarily different, are convergent, their meeting-point being the disclosure of normal functions. It is the business of the physician to attend to the urgent call of pain and disease, and to use for their relief such information as he has at his disposal. As he does so he observes, compares and draws conclusions on the basis of which a theory of the causation of the disorder may be built. The clinical observations and deductions drawn from them give a basis of rational physiological theory from which we have learnt that a state of disease is never a thing in itself, but is always a result of a quantitative change in some physiological process, an increase or diminution of something that was there to begin with. Reflection upon the observed bodily states in, say, a fever, jaundice, diabetes, nephritis or even mental disorders, reveals only overaction or underaction of some physiological function as the feature which distinguishes the affected from the normal individual. It is perhaps easier to speak of the normal than to define it. In the long run, the normal is the description given by a majority of individuals of their own build or behavior. It is abnormal to have unequal legs, to be eight feet high or to believe the earth is flat; but as no two individuals are exactly alike the definition of normality is more a matter of a statistical average than of precise definition.

[1] Address of the president of Section I.—Physiology. British Association for the Advancement of Science, Glasgow, 1928.

Disease is a departure from the normal which threatens life or which in some way reduces its value. The physician's duty with regard to it is a threefold one; he must diagnose, prognose and treat. In diagnosis and prognosis he relies chiefly on past experience, and must also bring great skill and judgment to bear on each particular case. The symptoms of disease which enable him to make a diagnosis are very often of an adaptative or compensatory nature, and the application of physiology to the problems of medicine is often of considerable value from this point of view, since it teaches that the mere alleviation of symptoms may be quite the wrong way to attack the problem. In cardiac or renal dyspnea, for example, the exaggerated breathing is of an adaptative nature —the patient is not ill because of the overbreathing, but overbreathes in consequence of the disease and would possibly succumb if he did not. More usually the meaning of symptoms is less clear, and it is the difficulty of recognizing the underlying causes of disease which makes the practice of medicine at once so exquisitely difficult and so fascinating.

In treatment, too, two important principles arising from actual observation receive support from physiological knowledge. One is that the consequential alterations which take place in the course of the disease are of the nature of adaptations which tend to restore the function to normal; these adaptations take the form of increase or diminution of some particular factor, of hypertrophy or atrophy often of some definite organ, always of some function—it is, in fact, the *Vis medicatrix* of the older physicians, the underlying principle of expectant treatment. The other principle is that nearly all positive measures of treatment, including drugs, produce their effects by augmenting or restricting some function or other.

The applied aspects of physiological knowledge concern the related subjects of hygiene and preventive medicine, medicine, surgery and veterinary and agricultural sciences in their widest senses.

Investigations on diet, ventilation, industrial fatigue and on the contraction of and resistance to infections, soundly based on the fundamental principles of physiology, have done much to make conditions of life more tolerable for the present generations than for their predecessors. Few medical students at the present time become acquainted with those severe or fatal cases of rickets, scurvy, diabetes or pernicious anemia which we all knew could be seen in the wards of any large hospital twenty years ago, and this gift of life and health to the afflicted is the grateful offering of physiological research to its respected parent, medicine.

No aspect of scientific activity is so generally misunderstood as that which concerns the making of discoveries, and in matters of medical research ignorance is particularly widespread.

The popular idea seems to be that an investigator sets out with the intention of making a particular discovery, such as a new element, or a cure for a certain disease, but every scientific worker knows that real discovery, as distinct from invention, is never achieved in this way. A discovery is the process by which an idea of new relationships is revealed, and involves two factors, observation and reflection. The origin may be a chance observation which suggests a hitherto unappreciated relation, and leads to the formulation of a hypothesis which, if possible, is then deliberately tested by experiment. The history of the discovery of insulin may be given as an illustration. The fundamental discovery here was made by a chance observation that removal of the pancreas produced diabetes; from that time onwards it was evident that if the missing pancreatic function could be replaced a cure would be possible, and it was justifiable deliberately to search for some means of doing this. But the search was in vain until another new idea came into physiology by reason of the discovery of the existence of autacoids. From this point on all was clear in theory, and it is no detraction from the merit of subsequent work to say that the final happy result depended principally upon inventive technique and manipulative skill, and only in a lesser degree upon discovery.

Discoveries are infrequent, in a sense fortuitous, and often dependent on rare qualities of intellect as well as on accurate observations, and they mostly come out of the fullness of time.

We all feel great pride in recalling that one of the greatest of all discoveries, which has recently been celebrated at the tercentenary of the publication of William Harvey's famous book *"de motu cordis,"* was made in our own country. Here was a genuine revelation that put old facts in a new light. It is of interest to reflect that the hospital at which Harvey was a physician had been carrying on its work as such for over 500 years at the time his discovery was made. What fundamental changes in the outlook of the physician and surgeon has that hospital seen during the ensuing 300 years in consequence of his revelation! And what further mutations in thought and practice will it have witnessed when Harvey stands as a beacon half-way in its eventful history? For we are privileged to live in times pregnant with opportunity for the science of medicine.

Incidentally it has been claimed, with more audacity than insight, that experiments upon living animals serve no useful purpose, and it has even been pretended that Harvey had no need for such experiments in the classical researches which formed the founda-

ons of physiology and gave reason to physic. Yet we have Harvey's own words. . . . "At length, and by using greater and daily diligence, having frequent recourse to vivisections, employing a variety of animals for the purpose, and collating numerous observations, I thought that I had attained to the truth, that I should extricate myself and escape from this labyrinth and that I had discovered what I so much desired, both the motion and the use of the heart and arteries."

The experimental method, which was revived by Harvey, now forms the permanent basis of physiological as of medical knowledge, and in spite of all criticisms must obviously remain so. Riolan, in advancing against Harvey the criticism that "it is a mockery to attempt to show the circulation in man by the study of brutes," was, as Gley has recently remarked, "already employing the argument, if it can be called one, which is encountered under the pen of the antivivisectionists of all times, and which illustrates the diuturnity of ignorance and folly."

Let any one with sufficient acquaintance with physiology try to write an account of such of the main facts concerning the functions of the heart and of the circulation as are most valuable in medicine, without reference to any fact obtained directly or indirectly by animal experimentation, and he will find his essay a very sorry one indeed: for no doctor can use a stethoscope, feel a pulse, take a blood-pressure, administer a hypodermic, give an anesthetic or a transfusion, perform any modern operations or indeed take any steps in diagnosis, prognosis or treatment, without utilizing at every turn knowledge derived from the results of animal experimentation and obtainable in no other way. And every medical man, even those few who for various reasons prefer the publicity of an antivivisection platform to the obscurity to which they are properly entitled, knows these things perfectly well, and if he practices, acts upon them every day of his life.

Another useful application of physiological knowledge is that of the science of ventilation, including the use of mine rescue apparatus, which began to take shape during the eighteenth century in the hands of Stephen Hales, while a little later Joseph Black, a professor, be it noted, of medicine and chemistry in this ancient University of Glasgow, discovered carbon dioxide, and Priestley oxygen. The use of submarines, of oxygen sets for aviators and mountaineers, of gas respirators and caissons and the means for the scientific study of industrial fatigue and of athletic performances, have all descended as practical outcomes of this respiratory physiology.

To take another example in more recent times one may mention Joseph Lister, a cherished link between University College, London, and the University of Glasgow, that indefatigable experimenter who made as valuable contributions to physiological knowledge as to surgery. The revolution in surgical technique which we owe to his largely physiological investigations is as striking as the changes in the outlook of medicine introduced by Harvey. Erichsen, a teacher of Lister, had said not long before that operative surgery had reached the limit of its perfection and that the surgeon's knife would never safely penetrate such parts as the brain, chest or abdomen.

The subject of pharmacology is very closely connected with physiology, on the one hand, and therapeutics, on the other. As a branch of physiological work it has the highest scientific as well as practical importance; for the study of the mode of action of drugs by providing a means of studying the effect of definite chemical alterations in the environment on the reactions of the living cells can not fail to serve as a powerful instrument of physiological research. Rational therapeutics, based on the results of pharmacological study, also will carry into the wards the spirit of true scientific investigation, and the provision of beds in some hospitals for the use of the professor of therapeutics is an indication that definite progress is being made in this direction. Such an advance has not come before it is needed. If the medical practitioner is to compete successfully with osteopaths, chiropractors and other similar unqualified persons, he is most likely to do so by only prescribing treatment with proper scientific basis. He should be able to form some opinion with regard to the claims of advertisers of remedies who contribute so large a share towards his daily mail deliveries, and many of whom would be unable to exist were it not for the fact that the average doctor is often as easily deceived with their pseudo-scientific puff as any layman.

If physiology may with pride point to the way in which it has contributed to the development of medicine, surgery, hygiene and veterinary science, it must with gratitude acknowledge that its inspiration has largely come from them too. A clinical friend of mine has written that "physiology can only come to the aid of medicine with becoming modesty, and without overweening dogmatism. There is no finality about either, but they can cooperate usefully . . ." and I thoroughly agree with him, not only because I recognize, as a physiologist, that my subject has been nourished largely by the problems of the bedside, but also because I think that modesty is the only attitude compatible with the ignorance of all of us when we view the handiwork of nature however revealed.

At this point I should like to digress a little to say a few words about the training of medical students in

physiology. This has two objects in view, first, to equip these students with a grasp of physiology such as will enable them later on to build a proper rational knowledge of medicine and surgery; second, to encourage them further to advance medical and surgical knowledge, and in special cases physiology itself. With certain reservations, I do not think that these two objects are at all incompatible at the present time.

A hundred years ago the common portal of entry into the medical profession was by a preliminary apprenticeship, begun at the age of about fourteen, to a doctor or apothecary, as often as not in the country. This lasted for five years, after which it was usual for the student to "walk the hospitals" at some great center, the chief in London being St. Bartholomew's and Guy's Hospitals. Here he could also attend some lectures on anatomy (including physiology), botany, medicine, surgery and midwifery and there were also courses of dissections. The requirements of licensing bodies were, however, fragmentary. The College of Physicians had no definite curriculum of professional study before 1845. In Scotland physiology was incorporated, as the "Institutes of Medicine," with some teaching of general pathology and elementary clinical medicine.

The medical students of Dickens—for example, Bob Sawyer, who "eschewed gloves, and looked upon the whole something like a dissipated Robinson Crusoe"—were caricatures of the students of this period.

There were few medical students in England outside of London a century ago; Oxford and Cambridge together averaged six medical graduates a year. Edinburgh produced about 100–120. In England it was only the handful of university men who received anything like a preliminary education before entering the hospital.

A notable step was taken in London with the foundation of University College, then called the University of London. In his introductory address at the opening of the university in 1827, Sir Charles Bell said: "With respect to our students, the defects of their mode of education are acknowledged on all hands. They are at once engaged in medical studies without adequate preparation of the mind; that is to say, without having acquired the habit of attention to a course of reasoning; nor are they acquainted with those sciences which are really necessary to prepare for comprehending the elements of their own profession. But in this place this is probably the last time they will be unprepared, for example, for such subjects as we must touch to-day. In future, they will come here to apply the principles they have acquired in other classrooms to a new and more useful science."

In the first year 165 students entered the new college, and classes were held in chemistry, zoology, anatomy (and physiology) and on various clinical subjects.

Jumping forward now about forty years to 1867, we find the curriculum has expanded very much. First, there came the influence of Liebig and chemistry, and by about 1850 or 1860 we find chemistry, mostly inorganic, a regular requirement by all licensing bodies. A chemical laboratory was first constructed at St. Bartholomew's for instance in 1866. The University of London now required at a preclinical examination a knowledge of chemistry, botany, natural philosophy, anatomy, organic chemistry, physiology and materia medica. A contemporary writer gives an account of the students of this period from which it appears that the medical student has since changed more in appearance than in ways, for he says that the principal aim of some of them was preservation of their glossy hats and exquisite coat-tails, gloves and sticks, while the throwing of paper balls was already an established tradition among them.

Although lectures on physiology are mentioned at this time, there was no separate chair of physiology in England until 1874, when Sharpey, who had been professor of anatomy and physiology at University College, was succeeded by Burdon Sanderson as the first professor of physiology. The first practical classes in physiology were held there by a pupil of Sharpey, Michael Foster, and consisted of histology, experimental physiology and rudimentary physiological chemistry. To quote Foster's own words, "What could be done then was very, very little. I had a very small room. I had a few microscopes. But I began to carry out the instruction in a more systematic manner than had been done before. For instance, I made the men prepare the tissues for themselves. That was a new thing in histology. And I also made them do for themselves simple experiments on muscles and nerves and other tissues in live animals. That, I may say, was the beginning of the teaching of practical physiology in England."

We realize from these dates that physiology in Britain had fallen very far behind when compared with the Continent, for Ludwig, in Germany, who obtained a separate chair of physiology in 1865, and Claude Bernard in France, had raised the subject to a high level by the time that physiology in England was being reborn, through the activities of Sharpey and his pupils, Foster and Burdon Sanderson.

The teaching of physiology is, very properly, largely influenced by contemporary research work, and the exact matter taught must, therefore, be ex-

pected gradually to undergo change as the focus of research interests shifts.

It was only natural that the new English physiology should receive the stamp of the men who created it, and that histology through Sharpey, and nerve-muscle physiology through the influence of Burdon Sanderson, should occupy a prominent place. For about thirty years in fact the nerve-muscle physiology threatened to eclipse all other branches of experimental work, and it was this flight into questions which appeared to be chiefly of academic interest which was, I think, largely responsible for the regrettable estrangement between the newly liberated science and its parent subject of medicine which marked that period of its development, and of which traces still linger to this day in some of the more elderly representatives of both subjects. At the present day we must admit that the knowledge gathered by those of our predecessors who worked at the physiology of muscle and nerve has proved of great value in directing physiological inquiry along scientific lines, from which the science of medicine has profited as much as physiology itself. The interesting revival of the study of the same subjects by more accurate methods within the past few years has further enriched our insight into the fundamental phenomena of life and vindicated the opinions of our predecessors as to the value of such investigations.

The development of physiological chemistry, now often called biochemistry, in this country was largely due to the influence of Professor W. D. Halliburton, whose "Chemical Physiology and Pathology" was for many years the only comprehensive English textbook on the subject. The growing importance of organic chemistry led to its introduction into the medical curriculum, in connection with biological chemistry, and in recent years the similar position of physical chemistry has led to its inclusion in some form or other in the curriculum of most medical schools.

Whereas in the sixties the student's chief study was anatomy with some botany and chemistry, there have now grown up as special courses of instruction, each with its professor or other specialized teacher, courses in the preliminary sciences and in anatomy, neurology, histology, embryology, organic chemistry, physical chemistry, physiology, experimental physiology and biochemistry, with pharmacology often thrown in as a makeweight to fill up any spare time the student may have left. Sometimes even special courses of human physiology are added. Here is the great dilemma of the medical curriculum: with all these special departments, each urging that its subject is of prime importance in the course, how can the poor student rightly direct his steps, and be enabled to see the wood for the trees? Yet, so great is the expansion in each of these subjects, that unless some at least of them are dealt with by specialists the student's instruction will unquestionably be obsolete in parts.

The solution to the difficulty lies, in my opinion, in two directions: first in the extensive modification of the present system of examinations, and secondly in the exercise of a sympathetic understanding on the part of specialist teachers of the difficulties of the student and a proper perspective of the relation of his own subject to the requirements of the curriculum as a whole. We have a sacred trust: it is the duty of those of us who are teachers of physiology to hand on to our successors, not the science as we inherited it, but a science which we and our contemporaries have ourselves improved and enriched to the best of our ability.

Out of the multitudinous and tumultuous activities of scientific labor new principles gradually emerge, and the truth appears in a constantly changing garb. As I have said before, research reflects itself in teaching, and it is accordingly necessary that teaching should be reviewed from time to time, that new matter be introduced in so far as it is of general importance, and old matter rejected as soon as its immediate value diminishes. I should very much like, for similar reasons, to see profound alterations in the teaching of chemistry, both inorganic and organic, to medical students.

It is, in my opinion, quite impossible, and perhaps undesirable, at the present time to frame instruction in physiology so as adequately to equip the ordinary medical student to proceed directly to the prosecution of research in any of its branches; this can only be achieved by a further year or two of study of the subject, such as by a science course for an honors degree. One of the objects of instruction is to enable the latest results of physiological investigation to be utilized in the clinic, and it seems to me that one of the best ways for this to be effected is for some workers specially trained in physiological methods to enter the staff of clinical units where facilities for research work are at hand. The opinion was at one time prevalent among many clinicians that if their problems required the use of methods similar to those of experimental physiology these should be farmed out to a physiologist, and although there are cases where this procedure may be followed with advantage, the rich harvest which has already been reaped by the importation of physiological knowledge and methods into, rather than the export of problems from, the clinic, is adequate justification for the former. It is in any

case encouraging to note the present-day decline of the attitude that experimental investigation is work of a lower order, which can be put out like so much washing, for the employment of an inferior caste. We at the present day, however we may be labeled, are not merely willing to admit, but eager to assert, that we can not recognize fundamentally distinct methods of physiology, of psychology, of medicine, of chemistry or of physics; we only admit a method of experimental inquiry common to all science and slightly modified to suit particular cases.

The close connection which is now generally admitted between physiology and medicine was clearly foreseen by Claude Bernard in 1855. Medicine, he said, is a science, and physicians who describe it as an art injure it, because "they exalt a physician's personality by lowering the importance of science." "True experimenting physicians," he says, "should be no more perplexed at a patient's bedside than empirical physicians. They will make use of all the therapeutic means advised by empiricism; only, instead of using them according to authority and with a confidence akin to superstititon, they will administer them with that philosophic doubt which is appropriate to true experimenters." And this attitude, I venture to think, is the one which is almost universal to-day.

Charles Arthur Lovatt Evans

*(To be concluded)*

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## GEOLOGICAL AND ARCHEOLOGICAL RECORDS OF THE YUCATAN PENINSULA

Careful work during the past two decades upon the part of such men as Blum, Gann, Spinden, Morley, Gregory Mason and others, within the region comprising the old homeland of the Maya race, from northern Guatemala (Peten), British Honduras, Campeche, Yucatan and Quintana Roo, has established a few broad facts upon which all are agreed. These may be summarized as follows:

(1) The origin of the Mayan race and its culture somewhere south of Peten in Guatemala, at some indefinite time preceding the Christian era.

(2) The gradual migration of temple cities and cultural centers progressively northward, during the fourth and fifth centuries of the Christian era and the abandonment of previously occupied capitals to the south until a last stand was made at Chichen Itza and Mayapan near the northerly tip of the Peninsula.

(3) The weakening of the race during the latter part of this migration until during the time of the occupancy of the two northern capitals at Chichen Itza and Mayapan, the territory was conquered by the Toltecs from the north, and the Maya race became a dependency of the Mexican, somewhere during the twelfth century A. D.

(4) During the Toltec domination, not long before the coming of the Spaniards in the sixteenth century, the remnants of the Maya peoples were still further decimated by the ravages of disease, leaving but a comparatively few spiritless people to resist the Spaniards, with relatively little memory of their ancient culture, with temples and cities abandoned to the jungle.

(5) During the past two centuries has occurred still further decrease in the population of the aboriginal race in Yucatan, by yellow fever, dysentery, malaria and diseases brought by the white race. Recently the influenza epidemic has killed thousands.

Wide areas of forested lands to-day cover territory once supporting an agricultural population numbering millions, where to-day a few hundreds of chicle gatherers eke out a meager existence during the season of sap flow. The question as to the reason for this progressive northward migration, and later the virtual disappearance of the Maya race, is one which has bothered all investigators. That the two phases of Mayan history may have been related by a common cause has suggested itself. Foreign wars on a national scale there were none, except what incidental fighting occurred toward the end, when the Toltec political ascendancy took place. Contacts with outside peoples, with the bringing of strange plagues to a race with little immunity, could have been very slight. The infiltration of foreigners along the narrow neck of Central America and incidental canoe-borne traffic could have offered few opportunities for the breaking out of epidemics carried by outsiders, who were few and of essentially the same habits of life as the Mayas. The great progressive migration took place during the flowering of the Mayan culture of the First Empire, when they were at the height of their strength and population.

Morley suggests that the land was cleared and corn (maize), upon which the race was dependent for food, planted. Then after a few plantings the heavy grass choked out the corn, and this necessitated the clearing of fresh lands. This hypothesis can not be accepted by any one familiar with the Indian method of planting corn in the tropics. In new land, the underbrush is frequently cleared, the corn sown and the forest felled over the sowing. The first crop sends its stalks up through the felled timber and brush, sometimes to a height of twenty feet. Meanwhile the timber is rotting and collapsing, so that each new crop of corn encounters less difficulty in reaching the air and sun and is better bearing. There is no grass that the writer has ever seen which would retard Indian corn. The comparative ease of clearing enough grass for a hill of corn as compared with clearing new timber

lands, for a people with no metal implements, answers this question beyond any controversy.

There is, however, a perfectly plain geological record throughout this region, which answers the question as to the reason for this migration, and as well answers the question why no important number of people can live in this region to-day, which is apparently one of the healthiest forest regions which the writer has ever had an opportunity of visiting during twenty years spent in Central and South America.

An explanation of this record must be prefaced by a description of the peculiar conditions which exist within this region, making it unique among all tropical regions of similar size in the western hemisphere. This is summarized by saying that while there is a heavy annual rainfall there is little or no surface water except for a few principal rivers around the edges of this region, and scattered small lakes or "cenotes," with no surface outlets. This entire peninsula is composed of porous limestone, ranging in age from Lower Cretaceous to upper Tertiary; but all alike in the one respect of being filled with underground channels through which all fresh-water drainage takes place seaward. Occasionally during the rainy season a surface stream is seen following a shallow bed, but it will be found soon to disappear in the limestone and can not be picked up again except by inference at one of the great springs along the coast line or near one of the main branches of the Usamacinta River.

The comparatively large Lake Peten, in central Peten, has no outlet. This lake, as well as all smaller pools and "cenotes," seems to have a uniform water-table, without reference to the rainy seasons. However, all the larger lakes such as Peten have definite terraces and high level dry beds of previous tributary basins. There are innumerable dry "cenotes" or deep sink holes, which previously contained water. The great temple city of Tikal is located beside what was once an extensive lake, of which only a small stagnant pool remains. The geological record thus shows a progressive tilting of the land from the south, which has raised the surface above the permanent watertable in the cavernous limestone bedrock, draining the lakes and "cenotes" *from the bottom* progressively northward, until there are only remnants of their number remaining. These are not enough in number or size, with a few notable exceptions, to support a large population. In spite of the rainfall, in traveling through Peten and Yucatan, one is forced to carry drinking water from one water hole to another, which in some cases are several days journey apart.

With the diminution of the water supply, and a large population, the nature of these stagnant pools remaining, plus the lack of knowledge of sanitation on the part of the people, plus perhaps their custom of throwing sacrificial victims into the same or connecting bodies of water, might easily have caused epidemics. "The gods are angry, and we must move"—and always northward, the direction of the progressive tilting. Once crowded to the tip of the peninsula, and their numbers and their virility depleted by both lack of food sources and by epidemics, they were easy victims to the raids of the Toltecs.

L. G. HUNTLEY

PITTSBURGH, PA.

## LANCETILLA EXPERIMENT STATION

THREE years ago the United Fruit Company established Lancetilla Experiment Station on the north coast of Honduras, near the port of Tela. This station, under the direction of Wilson Popenoe, is one of the several branches of the research department of the company. Its purpose is the introduction and testing of new agricultural products which may be grown successfully in tropical America, and the study of conditions affecting banana production, the chief and only important industry of the Atlantic coast of Central America.

Lancetilla Station, situated six kilometers south of Tela, is reached by a tram line over which motor cars are operated. The site lies in a narrow valley at an altitude of nineteen meters. On each side rise densely forested hills, with a maximum elevation of six hundred meters. The lower ground of the valley formerly was planted with bananas, but the hills, except for a few clearings made by squatters, retain their primeval vegetation. They are intersected by many swift streams of clear water.

At the station there has been assembled a large collection of economic tropical trees, including the best representation of tropical Asiatic trees to be found anywhere in America. All the trees are still small, but they are growing rapidly, and in a few years will make an impressive showing.

There has been established at Lancetilla, also, the Serpentarium of the Antivenin Institute of America, maintained by the Tela Railroad Company, the Museum of Comparative Zoology of Harvard University and the H. K. Mulford Company. The serpentarium prepares serum from the Honduran rattlesnake and the *barba amarilla* for use in tropical North America.

The purpose of the present note is to direct attention to the suitability of Lancetilla as headquarters for research work in the natural sciences. Living conditions are exceptionally favorable, with good water, protection against malarial mosquitoes and all modern conveniences. The Tela Railroad Company

has been generous in supplying to visiting scientists every facility for the performance of their work, and the director of the station is keenly interested in the assembling and publication of information regarding the fauna and flora of the region.

From the first of December, 1927, until the end of March, 1928, the writer was engaged in a botanical survey of the Lancetilla Valley. During the same winter Messrs. Peters and Bangs, of the Museum of Comparative Zoology, made a comprehensive collection of the birds of the vicinity. It is expected that reports upon these collections will be published soon, thus making a substantial contribution to the knowledge of the local natural history.

For botanical work, I can testify that the Lancetilla Valley is unexcelled on the Atlantic coast of Central America. The flora is a rich and varied one, including representatives of most of the groups to be expected in the *tierra caliente*. The tree flora is unusually large, and there is a good representation of palms, ferns and cryptogams. Fungi are so conspicuously abundant that their study undoubtedly would have profitable results.

Virgin forest may be reached on foot in ten minutes from the station. On the hills three more or less distinct belts of vegetation may be recognized. Along the streams there is a profusion of aquatic plants, and about Tela there is an interesting strand vegetation, with a few mangrove swamps.

The whole of Honduras is practically unknown, so far as the fauna and flora are concerned, and any collector is certain to find here an abundance of new forms in any group. No better field for research work can be found along the Central American coast, and the choice of the Lancetilla Experiment Station as a base for field work can not be recommended too highly to those concerned in the study of the natural history of Middle America.

PAUL C. STANDLEY

FIELD MUSEUM OF NATURAL HISTORY

## SCIENTIFIC EVENTS

### SUMMER WORK OF THE GEOLOGICAL SURVEY

FORTY or more members of the Geological Survey, with their assistants, are now scattered throughout the United States, making field studies to serve as a basis for determining the probable mineral character and value of the public domain which remains under the care of the Department of the Interior and that furnish other geologic information of use to the public.

Four geologic groups are in the State of Montana. Two of these, under the direction of geologists experienced in the field of metals, are conducting surveys in the region tributary to Helena. This project is supported by local cooperation. In southern and east-central Montana two geologic groups are mapping the coal fields of that portion of the state.

In central Idaho one geologic party is studying the deposits of metals which are associated with the great granite intrusions of the central part of the state. Another geologic party, in eastern Idaho, is continuing the mapping of the phosphate deposits.

In Nevada three areas are under examination—one, the Charleston Peak region west of Las Vegas; another, the Ivanpah region immediately to the south; and a third, the Silver Peak area west of Goldfield. Associated with the geologists engaged upon these projects are two survey paleontologists, who are collecting the fossil evidences of extinct life.

In northern California, in Plumas County, an examination of the copper deposits is under way.

In southeastern Utah systematic work is being done along the canyons tributary to the San Juan and the Colorado, extending westward to include Navajo Mountain. It is a part of the systematic study of the plateaus of the canyon region directed to a determination of the structure of the rocks underlying these plateaus.

The coals of the great San Juan Basin and other resources in New Mexico are being investigated. In the Magdalena mining district cooperative work is being carried on with the director of the State Bureau of Mines and Mineral Resources. Work on the Santa Rita mining district, begun some years ago, is being brought to completion, and attention is being given to the existence of potash deposits in the great salt basin of the southeastern part of the state.

In Colorado an extensive cooperative project, begun two or three years ago, is being continued energetically. The expenses of this work are shared between the state and the United States Geological Survey. Five geologists from the latter organization are assigned to the study and two topographers are making the base maps which the geologists need. In this work an attempt is being made to apply geologic research directly to the problem of ore finding.

In Texas progress is being made on the slow task of preparing a new geologic map of the state on a scale that will be adequate for the use particularly of the petroleum industry. This work was begun three or four years ago and may take as many more years for its completion. Texas is an empire in itself, covering more than 265,000 square miles. The preparation of a detailed geologic map is therefore a task of much magnitude.

In addition to the cooperative work on the state map in Arkansas, another cooperative project there

involves the study of possible lead and zinc deposits in the northern part of the state. Cooperative work is also under way with the Illinois Geological Survey, with which the Federal Geological Survey cooperates extensively in the preparation of topographic maps, and less extensively in a study of the geologic problems of the state. The iron ores of the south are receiving more or less constant attention. An agreement has been entered into with the Geological Survey of Alabama for a cooperative study of the ores of that state. A review is under way of the iron ore situation in Virginia and some of those of Tennessee are treated in reports about to be issued. Pennsylvania, New York and New England are not neglected in this work. To each of these states or groups of states the survey has assigned members of its geologic staff who are at work on research problems. Among the problems thus attacked is that of the mild earth tremors, a number of which have been felt in New England in recent years.

## THE INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

FROM an account in *Industrial and Engineering Chemistry* of the ninth conference we learn that the following officers were elected: *President,* Emar Biilmann, of Denmark; *Vice-presidents,* d'Artigas, Behal, Bodtker, E. Mond, Parravano, Reese, Sakurai and Swietoslawski. Of these, Behal, Bodtker, Mond and Sakurai were selected by lot to serve two years. Dr. Mond was chosen to be the successor to the president in case the necessity should arise. Jean Gérard was reelected secretary.

The next meeting will be held at Liége, Belgium, in 1930. It will consist of both a Conference of the International Union and a Congress of Industrial Chemistry organized by the Société de Chimie Industrielle, of which Jean Gérard is vice-president. The invitation to convene at Liége was offered in the broadest terms to include chemists of all nations, whether at present adherents to the union or not. It is expected that the 1932 meeting will be a large International Congress of Chemistry, organized at Madrid by the chemists of Spain in association with a committee of the International Union.

*Engineering and Industrial Chemistry* gives the following account of the organization of the union:

During the past few years many criticisms of the International Union have been expressed, especially in England and America. The need of a reorganization of its activities has been recognized for some time by several of those most interested in its success. Suggestions along this line were made by Dr. Cohen, the president, at the Washington meeting two years ago, and preliminary modification of its statutes were offered last year at Warsaw. During the present meeting the principal business was the further consideration of these changes and the adoption of the new statutes and regulations.

The result has been to alter considerably the character of the organization. In the past its efforts have been devoted principally to securing international agreement upon subjects of common interest, but hereafter its activities will also be directed towards the organization of international congresses of chemists. Future meetings will be held at two-year intervals, and each alternate one will be an international congress organized on an elaborate scale.

A marked desire to improve the character of the union in another direction was also expressed. This was to enlarge its international character by encouraging the entrance of those nations not at present affiliated with the union. Toward this end the following distinguished chemists were present at The Hague as invited guests: from Germany, Professors Bodenstein, Haber, Markwald and Stock; from Austria, Professor Wegschneider; and from Russia, Professors Ipatieff, Schilow, Stepanow, Tschitschibabin and Zelensky.

As a further mark of the desire of the union to receive into its membership the countries not at present represented, the following resolution was unanimously adopted by the council: "The International Union of Chemistry is happy to salute the chemists of Germany, Austria and Russia, who have come as guests to the conference at The Hague. It hopes that the chemical groups in these countries will soon organize themselves in the manner leading to their admission into the union."

Although Dr. Cohen and other members have favored the above improvements for some time, it was the English delegation which insisted most strongly on their immediate adoption. In fact, Sir William Pope, in explaining why the dues of Great Britain had not been paid, said it was the result of their dissatisfaction with the union, and that no further payments would be made until assurance was obtained that the meetings would be organized in a manner worthy of scientists. He asked what would have been the opinion of van 't Hoff of an international gathering of chemists at which less than twenty papers describing advances in the science had been provided. Although the English were not present last year at Warsaw to aid in the inauguration of the changes, they came to The Hague fully determined to see them put through.

According to the new statutes, the International Union of Pure and Applied Chemistry has for its objects: (1) The organization of a permanent cooperation between the chemical associations of the adherent countries; (2) the coordination of their scientific and technical means of action; (3) contribution to the advancement of chemistry in all the extent of its domain, notably the holding of conferences and congresses. It has its provisional headquarters at Paris.

## THE MARTIN MALONEY MEMORIAL CLINIC OF THE MEDICAL SCHOOL OF THE UNIVERSITY OF PENNSYLVANIA

THE University of Pennsylvania broke ground on September 13 for the erection of the new Martin Ma-

loney Memorial Clinic Building of the University Hospital, which will occupy the site of the old Pepper Laboratory of Clinical Medicine, and will cost slightly more than $1,000,000. The ceremony was attended by university officials, including Provost Josiah H. Penniman and men prominent in medical circles in Philadelphia.

Constituting the first unit in the eventual complete modernization and expansion of the University Hospital, the new structure will permit the concentration of a number of important medical clinics. The building, which will house the general medical out-patient department of the University Hospital, will be L-shaped in form, nine stories high and will be erected of red brick and Indiana limestone, decorated with terra cotta. The architecture is English Collegiate, modified to suit the demands of a building of the type contemplated and treated in a slightly modern fashion.

The building will house dispensaries for medical and allied groups; a Hydro-therapy and Physiotherapy Department; special wards of small size for cases requiring particular study and care; the Pepper Laboratory of Clinical Medicine, and the John Musser Department of Research Medicine. The entire sixth floor of the structure will be devoted to the Eldridge R. Johnson Foundation for Research in Medical Physics, which was made possible by the $800,000 gift to the University by Eldridge R. Johnson, formerly president of the Victor Talking Machine Company.

The inclusion of the Eldridge R. Johnson Foundation, together with the Pepper Laboratory, and the Musser Department in the new building will have the advantage of placing in immediate proximity to the wards, a group of highly trained workers to whom all difficult problems can be referred.

Clinics to be housed in the new building include a Cardio-Vascular Clinic, Gastro-Intestinal Clinic, Thyroid Clinic, Metabolic and Diabetic Clinic, Asthma, Pulmonary and Biometric Clinics. A prominent feature of the clinical activities will be the inclusion of the work of the Robinette Foundation for the study, treatment and prevention of diseases of the heart and circulatory system, established recently through the generosity of Edward B. Robinette, an alumnus of the university and a prominent investment banker. The sum of $250,000 already has been contributed toward the foundation by Mr. Robinette, to which a like amount is to be added when the work carried on under the foundation requires it. The activities of the Robinette Foundation will be carried on chiefly through the heart, kidney and biometric clinics with which it will be closely affiliated.

In addition to the various clinics, research and other departments, the building will contain numerous receiving rooms, a library, dental room, special X-ray department, administrative offices and similar other equipment. A pathological laboratory will be situated on the top floor of the building.

The Martin Maloney Memorial Clinic has been made possible largely through the generosity of Mr. Martin Maloney, of Spring Lake, New Jersey, who some time ago presented the University of Pennsylvania with the sum of $250,000, which was to form the nucleus of a fund for the erection of the new building and who later added other substantial contributions to his original benefaction. It is the third important building to have been added to the medical equipment within the past year. Early last fall the university opened its new $2,000,000 teaching hospital of the Graduate School of Medicine, while the new $1,000,000 Laboratory of Anatomy and Biochemistry, made possible by two gifts of $250,000 each from the Rockefeller Foundation and General Education Board and other gifts, is rapidly reaching completion.

## LOWELL INSTITUTE LECTURES

Dr. Robert DeC. Ward, professor of climatology at Harvard University, will offer a course of eight Lowell lectures on "Climate in Relation to Man," beginning on November 19 and continuing on Monday and Thursday evenings at eight o'clock. The subjects of the different lectures are:

1. "The Meaning and Scope of Climatology, and Some of its Practical Applications in the Service of Man."
2. "The Relations of Climate and Health as seen by a Climatologist; The Health Resorts of the United States."
3. "The Climatic Factor in Man's Physical Environment. Ancient and Modern Views. Climate and Civilization, Habitability, Migrations and the Distribution of Population."
4. "How Far Can Man Control His Climate? Man's Struggle against Climatic Handicaps; His Successes and His Failures."
5. "The Acclimatization of the White Race in the Tropics."
6. "Some Present and Future Relations of Man to His Climatic Environments in the Tropics; Problems of Labor and of Government; The Development of the Tropics."
7. "Polar Climate; Man and the Polar Zones."
8. "Is our Climate Changing? Geological, Historical and Present-Day Changes in Climate; Periodicities and Oscillations in Climate."

Beginning on January 7 Vilhjamur Stefansson will give a course on the Arctic regions. The titles of the lectures are as follows:

1. "The Arctic and Sub-Arctic as they really are, to the Best of Our Present Knowledge and Belief—Climate, Resources, People."

2. "Greek Views of the Nature of the Arctic after 500 B. C. Theories and folk belief regarding the Far North. Travelers and trade. Pytheas. The ebb and flow of geographic knowledge. Ottar (Othere) and the English knowledge of Norway. The Irish discover Iceland—a stepping stone to the Arctic and to America."

3. "The Norse Colonize Iceland. The foundation and growth of the Republic. Literature and life. Discovery of Greenland."

4. "The Colonization of Greenland. The discovery and attempted colonization of North America."

5. "The Greenland Republic, its History from 986 to 1500. The fate of the settlements."

6. "Summary of Arctic Discovery from Cabot to Franklin."

7. "Summary of Arctic Discovery, from Franklin to Peary."

8. "The Relation of the Arctic to the World as a Whole. Scientific problems. Commercial development and economic destiny. (This lecture is a more or less personal account of the results of the three Stefansson expeditions of 1906–07, 1908–12 and 1913–18."

## SCIENTIFIC NOTES AND NEWS

THE regular fall meeting of the executive committee of the council of the American Association for the Advancement of Science will occur in Washington on Sunday, October 21. All matters of business and policy that are to be brought before the council at the annual meeting in New York should come before the executive committee at its fall meeting, in so far as that is possible. Communications to be presented to the executive committee at its fall meeting should be in the hands of the permanent secretary, Dr. Burton E. Livingston, the Smithsonian Institution Building, Washington, D. C., by October 15, to make sure that they get properly placed on the order of business and properly presented.

THE International Congress of Americanists is holding this week its twenty-third session in New York City. Dr. Henry Fairfield Osborn is the honorary chairman, and delegates from seventeen foreign nations were expected to be in attendance.

SIR THOMAS HOLLAND, rector of the Imperial College of Science and Technology, London, distinguished for his work in geology and mining engineering, was elected president of the British Association for the Advancement of Science at the recent Glasgow meeting. Sir Thomas was born in Canada in 1868.

STEPHEN C. SIMMS has been appointed director of the Field Columbian Museum to succeed David Charles Davies, who died on July 14. Mr. Simms has been a member of the scientific staff of the institute since it was founded in 1893, first as assistant curator of anthropology and since 1913 as curator of public-school extension.

HONORARY membership in the American Electrochemical Society has been conferred on Mr. Thomas A. Edison, who is one of the original members of the society.

DR. ATHERTON SEIDELL, of the Hygienic Laboratory of the U. S. Public Health Service, has been made a chevalier of the Legion of Honor.

DR. CHARLES L. REESE, director of E. I. du Pont de Nemours and Company, past president of the American Institute of Chemical Engineers, has been made an honorary member of the Institution of Chemical Engineers of Great Britain, in recognition of his distinguished services to chemical engineering and the promotion of international relations.

THE University of Amsterdam celebrated recently the seventieth birthday of Professor E. Dubois. The speakers recalled the services to paleontology of Professor Dubois, and more particularly his discovery and reconstruction of *Pithacanthropus erectus.*

NILES A. OLSON has been appointed chief of the bureau of agricultural economics of the U. S. Department of Agriculture, to succeed Lloyd S. Tenny, who has accepted a position with the Associated California Fruit Industries.

DR. ROBERT B. SOSMAN has resigned his position as physicist at the Geophysical Laboratory of the Carnegie Institution to join the staff of the newly organized research laboratory of the U. S. Steel Corporation, Kearny, New Jersey.

DR. WALDEMAR KAEMPFERT, director of the Rosenwald Industrial Museum, of Chicago, announces the appointment of J. R. Folse, of Northwestern University, to be curator of the division of prime movers, and of Marion F. Williams, of the University of Chicago, librarian.

THE regents of the University of Wisconsin have formally adopted a program of forestry research to be carried out in cooperation with the Federal Lake States Forest Experiment Station and the Wisconsin Conservation Commission. Dr. Raphael Zon, director of the Lake States Station, has accepted an appointment as non-resident professor of forestry and has assumed general supervision of all forestry research projects.

Professor Nelson C. Brown, of the College of Forestry of Syracuse University, has been named a member of the New York State Reforestation Commission. Investigation of the possibilities of reforestation of New York State and the preparation of a survey of the location, value and area of all land available for reforestation constitute the purpose of the commission.

Dr. Roger I. Lee, professor of hygiene in the Harvard Medical School, has been made chairman for the ensuing year of the committee on public health of the Boston Chamber of Commerce.

Dr. A. U. Desjardins, of the Mayo Clinic, has been appointed technical adviser to the irradiation committee of the National Research Council.

The Reverend Edward C. Phillips, since 1925 director of the Astronomical Observatory of Georgetown University, has been appointed to the office of Provincial of the Jesuit Province of Maryland-New York.

Sir J. C. Martin, director of the Lister Institute, has been appointed by the British Minister of Agriculture and Fisheries to be chairman of the departmental committee which will report on the reconstruction of the Royal Veterinary College.

Dr. Dayton Stoner has resigned his position as assistant professor of zoology at the State University of Iowa and has accepted an appointment as associate entomologist in the U. S. Bureau of Entomology. His work will deal with truck crop insects, and he will be stationed at Senford, Florida. On May 1, 1929, Dr. Stoner will return to Syracuse, New York, to complete his work on the birds of the Oneida Lake region. This project is promoted by the New York State College of Forestry and the Roosevelt Wild Life Experiment Station.

Dr. E. A. Birge, president emeritus of the University of Wisconsin, has returned from Northeastern Wisconsin, where his party of ten men studied contents of 229 lakes. Dr. Birge spent his seventy-seventh birthday unpacking boxes containing hundreds of samples of lake water and low forms of lake life collected during the summer in the comprehensive study of lake productivity which he began about thirty years ago.

Ernest W. Lindstrom, professor of genetics in the Iowa State College at Ames, has returned after a year in Europe. He was assistant director of the International Board in Biology and Agriculture. Professor Lindstrom traveled in most of the countries of Europe where important research is being undertaken, except in Russia, in order that the board, through fellowships and assistance to laboratories, might best assist the progress of science.

Dr. John D. Long, U. S. Public Health Service, has been relieved as chief quarantine officer of the Panama Canal and will report to the surgeon-general for conference prior to a tour of Latin-American countries as a representative of the Pan-American Sanitary Bureau.

Roy C. Potts, in charge of the division of dairy and poultry products of the Bureau of Agricultural Economics, has returned to Washington after attending the World's Dairy Congress, recently held in London. He visited Denmark and Holland to study the butter and cheese control service which is supervised by the ministries of agriculture of the governments.

Dr. J. Walter Woodrow, professor of physics in the Iowa State College, has returned after a year in England. As a Guggenheim Fellow, he investigated the physical properties of cod-liver oil, working at Oxford, Cambridge and Liverpool.

Dr. O. T. Jones, professor of geology at the University of Manchester, England, has been visiting the United States. With Dr. E. O. Ulrich he has been studying Cambrian and Ordovician stratigraphy of the Appalachian Valley, their trip extending from northern Pennsylvania to Alabama.

Dr. Warren K. Stratman-Thomas, research pharmacologist in the University of Wisconsin, Madison, sailed on August 2 for the Belgian Congo to study the effect of certain drugs in the treatment of sleeping sickness.

Dr. Andrew Henry Patterson, professor of physics in the University of North Carolina for twenty years and for the last seventeen dean of the school of applied sciences, has died at the age of fifty-eight years. Dr. Patterson had leave of absence from the university and was resting in New Hampshire in the hope of recovering his health.

Dr. John Rennie, an authority on parasitology and entomology at Aberdeen University and the North of Scotland College of Agriculture, died on August 30, at the age of sixty-three years.

Frank Lewis Mason, of West Haven, Connecticut, the consulting geologist and mining engineer, died on September 12 at the age of seventy-two years. Mr. Mason was at one time connected with the geological surveys of New Jersey and Missouri.

A marble bust of the late Dr. John Collins Warren is to be placed in the Warren Museum of Harvard University Medical School.

THE fifth annual meeting of the Eastern Society of Anaesthetists will be held in Boston, from October 8 to 12, when a bronze bust of W. T. G. Morton will be presented to the Massachusetts General Hospital, in which institution the first demonstration of an operation under ether anesthesia was performed.

A JOINT celebration was recently held at Darmstadt to celebrate the one hundred and twenty-fifth birthday of Justus von Liebig on May 12, 1928, and the centenary of the synthesis of urea by Wöhler. Besides representatives of the German chemical societies, others from European countries and from Japan were present. The memorial address on Liebig was delivered by Haber, of Berlin; Professor Wohl, of Danzig, spoke on Wöhler. Wöhler's original preparations of urea and of aluminum had been borrowed from Göttingen for the celebration. The birthplace of Liebig, which had to be razed in 1920 because of its dilapidated condition, has been exactly reproduced, as a result of contributions from German chemists and chemical manufacturers, and is now to serve as a museum in commemoration of Liebig and of the industries which originated with him. There is a Liebig museum at Giessen as well as at Darmstadt.

AT the annual meeting of the Mount Desert Island Biological Laboratory the following officers were reelected: Dr. Hermon Carey Bumpus, *president;* Dr. Duncan Starr Johnson, *vice-president;* Dr. Louise DeKoven Bowen, *treasurer;* Dr. Herbert Vincent Neal, *secretary.* Dr. Neal was reelected director of the laboratory. Seven new members were added to the corporation: Dr. W. H. Cole, of Rutgers University; George B. Dorr, of Bar Harbor; Dr. Margaret M. Hoskins, of New York University; Mr. Roscoe B. Jackson, of Seal Harbor; Dr. C. C. Little, of the University of Michigan; Dr. F. E. Lutz, of the American Museum of Natural History, and Dr. William Morton Wheeler, of Harvard University, making a total of twenty-nine members. Mrs. Bowen, the treasurer, reported that the total donations to the laboratory from August 16, 1927, to August 1, 1928, were $5,636.00 and that the balance in the treasury on August 1, 1928, was $3,127.58. The trustees voted to use the McCagg tract of land at Salisbury Cove as building sites for laboratory workers.

ACCORDING to a radio to Science Service the airplane expedition of the U. S. Department of Agriculture, which went into the wilds of New Guinea last spring to hunt for new varieties of sugar-cane, has now emerged and is returning to the United States. Dr. D. W. Brandes, leader of the expedition, reports a complete success in every respect. One hundred and seventy-one distinct varieties of cane were secured, including twenty wild kinds, and one species wholly new to science. These specimens of sugar-cane are being brought out alive, and it is the intention of the Department of Agriculture to use them in improving the canes now in cultivation, with the special aim of getting disease-proof varieties. The expedition covered a great deal of new and little known territory, flying over the heads of the head-hunting tribes that hold the land between the coast and the higher mountain areas. They spent seven weeks on the upper Fly river, three weeks in the Owen Stanley range and two weeks on the upper Sepik river. Fourteen lakes not hitherto on any map were located, and a number of other new geographical features discovered. The expedition has sailed for Vancouver, B. C., by way of Sydney, Australia.

THE Medical Research Council, as we learn from *Nature,* announces that on behalf of the Rockefeller Foundation it has made the following awards of fellowships provided by the foundation and tenable in the United States of America during the academic year 1928–29. These fellowships are awarded to graduates who have had some training in research work either in the primary sciences of medicine or in clinical medicine or surgery, and are likely to profit by a period of work at a university or other chosen center in America before taking up positions for higher teaching or research in the British Isles. Dr. L. E. Bayliss, Sharpey Scholar at University College, London; Dr. A. V. Neale, Children's Hospital, Birmingham; Dr. F. J. W. Roughton, lecturer in physicochemical aspects of physiology, University of Cambridge; Dorothy Stuart Russell, Baron Institute of Pathology, London Hospital; Mr. Arthur Wormall, lecturer in biochemistry, University of Leeds.

DR. EDWARD GOODRICH ACHESON, known for his work with electric furnaces, presented the American Electrochemical Society during its recent session at Charleston, West Virginia, the sum of $25,000 as a trust fund to form the basis of an award every second year of a gold medal and a prize of one thousand dollars ($1,000) for a distinguished contribution to any of the branches fostered by the American Electrochemical Society.

JOHN D. ROCKEFELLER, Jr., has given $100,000 to the Leonard Wood Memorial for the Eradication of Leprosy. The trustees of the fund have appropriated $165,000 to build an incipiency station at Cebu, Philippine Islands. Heretofore all lepers have been taken to the leper colony at Culion. This has meant that those suffering from the disease, whether in advanced or mild stages, have been detained in this single colony. It is proposed to establish similar stations in

various provinces in the islands where those suffering from mild forms of leprosy may be treated.

The board of directors of the Cottage Hospital, Santa Barbara, announce gifts amounting to more than half a million dollars for research work. Edward L. Harkness, George O. Knapp and Max C. Fleischmann each gave $200,000, Edward Lowe, $5,000, and E. Palmer Gavitt, a new building to be devoted to research. The gifts of Mr. Harkness and Mr. Knapp are to be invested and the income only used for research. The Fleischmann donation, after providing for certain improvements to buildings, will be invested and only the income used.

## UNIVERSITY AND EDUCATIONAL NOTES

Dartmouth College has received a bequest of $1,619,550 from the estate of the late Edwin W. Sanborn.

By the provisions of the will of the late George Warren Brown, a shoe manufacturer, the residue of his estate, amounting to not less than $630,000, is given to Washington University, St. Louis.

Gifts to the University of Chicago announced by the board of trustees are $25,000 from the Milbank Fund, New York, for research on infantile paralysis, under the direction of Dr. Edwin O. Jordan and Dr. Ludvig Hektoen; $449.60 from Dr. Lester E. Frankenthal to cover purchases for the medical library, and $5,000 from Mr. Frederick Bode and $1,000 from Mr. Herman H. Hettler for the Frank Billings Medical Clinic Fund.

Dr. E. D. Ball, formerly director of research work in the U. S. Department of Agriculture and assistant secretary of agriculture, recently in charge of celery insect investigations for the Florida State Plant Board, has been appointed dean of the college of agriculture and director of the agricultural experiment station at the University of Arizona. He will assume his new work about October 1. Professor J. J. Thornber, at his own request, has been transferred to his old position of professor of botany and botanist in the experiment station. He will continue his research work on the Flora of Arizona and teach the courses in systematic botany.

Professor Joseph Eugene Rowe has resigned his position as head of the department of mathematics and director of extension at the College of William and Mary to accept the presidency of the Clarkson Memorial Institute of Technology at Potsdam, New York.

Dr. Arthur Thompson Evans, since 1920 professor of botany and plant pathology at South Dakota State College, has been appointed professor of botany and head of the department at Miami University.

Dr. W. H. Bair, of Purdue University, has been appointed professor and head of the department of physics at Clarkson College.

Dr. H. A. Bender, of the University of Illinois, has been appointed assistant professor of mathematics at the Municipal University of Akron.

## DISCUSSION

### THE DISCOVERY OF LIVING MICRO-ORGANISMS IN ANCIENT ROCKS

About one and one half years ago the writer began some experiments which he has carried on since, as time permitted, to determine whether or not living spores of bacteria or fungi or resting bodies of other micro-organisms might still exist inside of ancient rocks. The basis of my decision to start upon such an apparently hopeless quest will be given in a future detailed report on the results obtained. It suffices for the purposes of this preliminary note to state in general terms the startling fact that I have discovered living organisms in a Pre-Cambrian rock from the Algonkian in Canada and in one from the Grand Canyon of the Colorado. I have also discovered other types of micro-organisms in a Pliocene rock which derives from a depth of several hundred feet from which it has recently been uncovered. It is impossible in this note to furnish details of the technique employed, but it may be said that drastic sterilization measures for the outside of the rocks studied were employed. While some of the organisms which appeared in the cultures are doubtless derived from the free air which had momentary access to the rock in the process of the technique employed, certain organisms were found which occur in every plate culture made with the rocks examined and which are of a strikingly different type from any which are usually found in plates made with soils or rocks. These organisms make a very sparse growth on media which support excellent growth of other organisms and seem to belong to the interior of the rocks studied. At least one and perhaps two such singular types of organisms were found which possess many characters of the Actinomyces group. They are spore-bearing rods occurring in chains, and I have become convinced that they are indigenous to the rocks in the spore

form. The question of whether they have relatively recently gained access to the interior of the rock or have always been there remains to be determined by further investigation. Detailed studies with improved technique are now in progress to answer the numerous questions which have arisen as a result of my discovery. Many types of rock will be studied and especially specimens derived from great depths where surface contacts could have played no part in furnishing the results noted. The Pre-Cambrian specimens thus far used were surface samples, but the Pliocene specimen was a deep sample as explained above. The organisms in the Pre-Cambrian rocks and those in the Pliocene rocks are quite different from one another. No algae of any kind, and no nitrifying bacteria have ever been found even in cultures maintained for several months or more.

It need hardly be said that the significance of the facts stated above is extremely great from the physiological standpoint and also from the evolutionary standpoint.

I am indebted for rock specimens to Dr. David White, of the U. S. Geological Survey, and to Dr. G. D. Louderback, of the University of California. I am glad to acknowledge also my obligation for assistance in some of the culture work to Mr. Herbert Copeland, of the Sacramento Junior College.

CHAS. B. LIPMAN

UNIVERSITY OF CALIFORNIA

## NOTE ON THE RADIAL MAGNETIC GRADIENT OF THE SUN

DR. HALE and his collaborators at Mt. Wilson Observatory have studied the general magnetic field of the sun by spectroscopic measurements of the Zeeman effect. These researches established the fact that at any given level the distribution of the magnetic field was very similar to the terrestrial distribution. A study of the radial distribution showed that the field decreased radially several thousand times as fast as would be expected if the sun were uniformly magnetized. This rapid radial variation has made it very difficult to obtain a consistent view of the general magnetic fields of the sun and earth.

In a recent paper[1] the writer pointed out that under certain conditions of ionization, temperature, pressure and magnetic field, a true diamagnetic effect exists which is due to the motion of ions or electrons spiralling about an impressed magnetic field. On the earth the conditions in the Kennelly-Heaviside layer satisfy the requirements and it was shown that the diamagnetic effect of this layer would account for the solar component of the diurnal variation of terrestrial magnetism.

[1] *Physical Review*, Vol. 32, p. 133 (1928).

Such data as are now available from spectroscopic studies indicate quite definitely that conditions on the sun at altitudes corresponding to regions of large radial magnetic gradient are precisely those most favorable for a large diamagnetic effect. Preliminary calculations appear to show that the intensity of magnetization of the diamagnetic layer of the sun is quite ample to account for the observed gradient. Moreover, the type of variation of the diamagnetic effect with the altitude above the surface of the sun is of such a nature that it appears quite possible that the magnetic field at the surface proper is much greater than has been generally accepted. This possibility is theoretically of great importance since it may shed considerable light on the origin of the magnetic field. A quantitative and more detailed study of the effect is now being undertaken.

NAVAL RESEARCH LABORATORY, ROSS GUNN
ANACOSTIA, D. C.

## THE SO-CALLED SIEVE OF ERATOSTHENES

FEW mathematical developments due to the ancient Greeks are now more widely known or more frequently referred to than the so-called Sieve of Eratosthenes for finding all the prime numbers which do not exceed a given number $n$. Such references appear sometimes even in the somewhat popular literature as a result of the fact that the use of the method represented by this sieve involves only very elementary mathematical considerations. The method may be illustrated by writing the natural numbers in order of magnitude, beginning with 2 and ending with the arbitrary number $n$, and then canceling every second number after 2 in the list. After this has been accomplished every third number of those which follow 3 is canceled and then every fifth number of those which follow 5. In general, after the multiples of any number $k$ have been canceled the multiples of the first uncanceled number among those which follow $k$ are canceled. The numbers which remain uncanceled after completing these operations constitute the list of the prime numbers which do not exceed $n$.

In 1911 E. Hoppe directed attention in his "Mathematik und Astronomie," page 284, to the fact that this method was known to the Greeks long before the time of Eratosthenes, and hence that the common term Sieve of Eratosthenes is actually a misnomer. Before this time all writers who referred to this subject seem to have credited Eratosthenes with the discovery of this method, which is the only one found in the mathematical literature of the ancients for determining all the prime numbers which do not exceed a given number. In fact, nearly all the writers who referred to this subject since 1911 have also given

credit either explicitly or implicitly to Eratosthenes for the discovery of the method. In particular, this was done in the two histories of mathematics recently published in our country as well as in the excellent work of reference in two volumes on the "History of Greek Mathematics," by T. L. Heath, 1921. It was, however, not done in the extensively revised second edition of the "Geschichte der Elementar-Mathematik" in seven volumes by J. Tropfke, 1921–1924.

It seems desirable to direct attention to this matter in a widely read periodical in order to facilitate the correction of such a widespread error, especially since this correction implies greater harmony in the picture of the mathematical developments due to the Greeks prior to the time of Euclid, about 300 B. C. The given method naturally suggests itself to any one who thinks seriously about the problem of determining all the prime numbers which do not exceed a given limit, and it has probably been rediscovered independently by thousands of students of mathematics. In view of the high mathematical attainments of the Greeks at the time of Euclid one would naturally be inclined to assume that this method could not have escaped being noted by the predecessors of Euclid, and it is therefore interesting to find that such an assumption is now supported by substantial historical evidence. The fact that no explicit reference to the division of the natural numbers into the two classes now known as prime and composite has as yet been found in the literature of those peoples whose civilization preceded that of the Greeks is a striking comment on their mathematical attainments.

G. A. Miller

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## ECTOGONY OR METAXENIA?

In an article entitled "Xenia and Other Influences Following Fertilization"[1] Waller discussed fully the nature of xenia and the proper use of the term and at the same time proposed the word "ectogony" as a suitable term to describe those influences which are due to the developing zygote. Recently Swingle has proposed the term "metaxenia" for "the direct effect of pollen on the tissues of the mother plant outside the embryo and endosperm." This term is open to many objections, since the word "xenia" plainly has come to mean the appearance of ordinary dominant heredity in the endosperm and not the effect of some material which might ooze out of the zygote nor of an irritation produced by its development. The influence exerted on the mother by the developing embryo is a wide-spread phenomenon in both plants and animals and is not at all confined to cases where a xeniophyte is present. Even in the Anthophyta a considerable part of the species have so little endosperm that it can not have much if any influence on the surrounding sporophyte tissues. Any effect that is noticed in such cases presumably comes from the zygote and is thus not "metaxenia." Definite effects from the outside on living tissues are abundant outside of the reproductive processes also, ranging all the way from effects of parasites and gall insects to tight shoes, which presumably produce corns without emitting a special "corn hormone." The term "metaxenia" would, of course, also be inappropriate if applied to gymnosperms and especially in such cases as the higher liverworts where the perigynium or so-called perianth seldom reaches its normal form if fertilization of the archegonium does not take place.

Dr. Waller's term, ectogony, is correct and appropriate from every point of view, since it simply implies an effect following fertilization and thus can be used as appropriately for the effect in a liverwort gametophyte as for one in an angiospermous sporophyte, while the term metaxenia would manifestly be confusing and even absurd if applied to the first case.

If differential effects are present through a specific influence brought in with the paternal heredity they can be designated as differential ectogony. Since this effect is, no doubt, certain to receive considerable attention in the near future, the term ectogony should by all means be accepted by both botanists and zoologists.

[1] *Ohio Jour. Sci.*, 17: 273–284, 1917.

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# REPORTS

## COMMITTEE OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

At the meeting of the board of directors of the American Institute of Electrical Engineers, held in New York on August 7, President Schuchardt announced the committee appointments for the administrative year commencing August 1, 1928. The chairmen of the committees appointed are as follows:

### General Committees

*Executive:* R. F. Schuchardt, electrical engineer, Commonwealth Edison Company, Chicago, Ill.

*Finance:* E. B. Meyer, chief engineer, Public Service Production Company, Newark, N. J.

*Meetings and Papers:* H. P. Charlesworth, plant engineer, American Telephone and Telegraph Company, New York.

*Publication:* W. S. Gorsuch, engineer, economics, Interborough Rapid Transit Company, New York.

*Coordination of Institute Activities:* H. A. Kidder, superintendent of motive power, Interborough Rapid Transit Company, New York.

*Board of Examiners:* E. H. Everit, assistant to general manager, Southern New England Telephone Company, New Haven, Conn.

*Sections:* W. B. Kouwenhoven, associate professor of electrical engineering, Johns Hopkins University, Baltimore, Md.

*Student Branches:* J. L. Beaver, associate professor of electrical engineering, Lehigh University, Bethlehem, Pa.

*Membership:* J. E. Kearns, electrical engineer, General Electric Company, Chicago, Ill.

*Headquarters:* R. H. Tapscott, electrical engineer, New York Edison Company, New York.

*Law:* C. O. Bickelhaupt, vice-president, Southern Bell Telephone and Telegraph Company, Atlanta, Ga.

*Public Policy:* D. C. Jackson, professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass.; consulting engineer, Jackson and Moreland, Boston, Mass.

*Standards:* F. D. Newbury, manager, power engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

*Edison Medal:* Samuel Insull, president, Commonwealth Edison Company, Chicago, Ill.

*Lamme Medal:* Charles F. Scott, professor of electrical engineering, Sheffield Scientific School, Yale University, New Haven, Conn.

*Code of Principles of Professional Conduct:* Harold B. Smith, professor of electrical engineering, Worcester Polytechnic Institute, Worcester, Mass.

*Columbia University Scholarships:* W. I. Slichter, professor of electrical engineering, Columbia University, New York.

*Award of Institute Prizes:* H. P. Charlesworth, plant engineer, American Telephone and Telegraph Company, New York.

*Safety Codes:* F. V. Magalhaes, general superintendent of distribution and installation, Manhattan, New York Edison Company, New York.

*Licensing of Engineers:* Francis Blossom, Sanderson and Porter, New York.

*Advisory Committee to the Museums of the Peaceful Arts:* John Price Jackson, manager, personnel bureau, New York Edison Company, New York.

TECHNICAL COMMITTEES

*Automatic Stations:* W. H. Millan, superintendent of substations, Union Electric Light and Power Company, St. Louis, Mo.

*Communication:* H. W. Drake, apparatus engineer, Western Union Telegraph Company, New York.

*Education:* Edward Bennett, professor of electrical engineering, University of Wisconsin, Madison, Wis.

*Electrical Machinery:* W. J. Foster, consulting engineer, General Electric Company, Schenectady, N. Y.

*Electric Welding:* A. M. Candy, welding engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

*Electrochemistry and Electrometallurgy:* G. W. Vinal, chief section of electrochemistry, Bureau of Standards, Washington, D. C.

*Electrophysics:* V. Karapetoff, professor of electrical engineering, Cornell University, Ithaca, N. Y.

*General Power Applications:* J. F. Gaskill, power engineer, Philadelphia Electric Company, Philadelphia, Pa.

*Instruments and Measurements:* Everett S. Lee, in charge insulation division, General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

*Applications to Iron and Steel Production:* M. M. Fowler, electrical engineer, General Electric Company, Chicago, Ill.

*Production and Application of Light:* B. E. Shackelford, chief physicist, Westinghouse Lamp Company, Bloomfield, N. J.

*Applications to Marine Work:* W. E. Thau, director of marine engineering, Westinghouse Electric and Manufacturing Company, New York.

*Applications to Mining Work:* Carl Lee, electrical engineer, Peabody Coal Company, Chicago, Ill.

*Power Generation:* F. A. Allner, general superintendent, Pennsylvania Water and Power Company, Baltimore, Md.

*Power Transmission and Distribution:* H. R. Woodrow, electrical engineer, Brooklyn Edison Company, Inc., Brooklyn, N. Y.

*Protective Devices:* E. A. Hester, planning engineer, Duquesne Light Company, Pittsburgh, Pa.

*Research:* F. W. Peck, Jr., consulting engineer, General Electric Company, Pittsfield, Mass.

*Transportation:* W. M. Vandersluis, electrical engineer, Illinois Central Railroad, Chicago, Ill.

In accordance with the by-laws of the Edison medal committee, the board of directors confirmed the appointment by President Schuchardt of new members of the Edison medal committee, for terms of five years each, as follows: Charles F. Brush, electrical engineering physicist, Cleveland, Ohio; D. C. Jackson, professor of electrical engineering, Massachusetts Institute of Technology, Cambridge, Mass., consulting engineer, Jackson and Moreland, Boston, Mass., and Elmer A. Sperry, chairman of board, Sperry Gyroscope Company, Brooklyn, N. Y. The board also elected three of its membership to serve on the Edison medal committee for terms of two years each, namely, Bancroft Gherardi, vice-president and chief engineer, American Telephone and Telegraph Company, New York; H. A. Kidder, superintendent of motive power, Interborough Rapid Transit Company, New York, and E. B. Merriam, engineer, switchboard department, General Electric Company, Schenectady, N. Y.

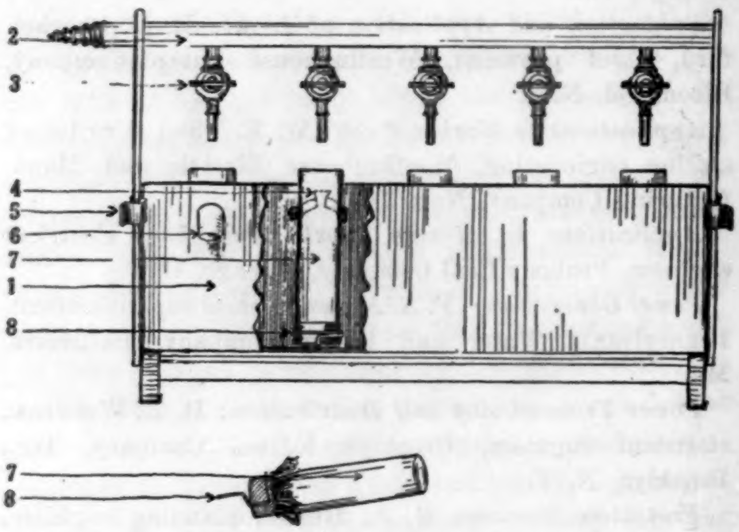
F. L. HUTCHINSON,
*National Secretary*

## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### AN APPARATUS FOR WASHING HISTOLOGICAL MATERIALS

FOR years in preparing materials for histological study I had felt the need of a simple, practical piece of apparatus for washing from such materials the reagents used in killing and fixing them. Being unable to find any such apparatus listed by the leading dealers in biological equipment I had made and installed on a shelf above the sink in my laboratory a device that meets this need.

The apparatus, as shown in the accompanying




sketch, consists of a framework of brass supporting a tank (1) made of tin-lined copper. This tank is held in place by the springs (5) and may readily be detached for cleaning. Above the tank are a series of petcocks (3) attached to a brass water-pipe (2) supported by uprights of the frame and fitted with a coupling for attaching the pipe by pressure-resistant rubber tubing to the water-supply. To the inner side of the back wall of the tank near the top are attached a series of spring-clips (4), one immediately below each petcock. These clips hold in place the washing tubes (7) and permit their ready insertion and removal from the tank, which, when in use, is filled with water to the level of the overflow pipe (6), through which, when the apparatus is in use, the excess water overflows into the sink.

The washing tube consists of a simple piece of glass tubing of suitable diameter over one end of which is placed a strainer of cheese cloth, marquisette or other suitable material. This strainer is held in place by a brass wire spring (8), which is continued downward and under in such fashion as to form a "leg" under the center of the bottom of the tube. This leg rests on the bottom of the tank and thus prevents the strainer from coming into contact with the bottom of the tank.

Material to be washed is put into the washing tube and the tube is placed in the spring-clip holder under the petcock, from which water is admitted into the tube. Washing is positive, the water entering the tube at the top and passing gently downward over and around the material and out at the bottom of the tube. The rate of flow of the water can be regulated at will by means of the petcock, and the leg on the spring holding the strainer prevents the tube from dropping to the bottom and stopping the flow of the water through the tube. In putting material into the tube, the killing fluid together with the material in it is poured into the tube, from which the fluid escapes through the strainer, leaving the material to be washed in the tube. When washing is complete, the tube is lifted from the tank and inverted in a wide-mouthed bottle or other suitable receptacle and a stream of water from a faucet, or preferably from a washing bottle, is directed upon the strainer, thus washing the material out of the tube into the receptacle. In this way materials can be handled without touching them with instruments and the most delicate can be manipulated without injury.

The tank is fifteen inches long, four inches wide, and four inches deep. I have found a tube four inches long and one inch in diameter the most satisfactory for general work, but tubes of greater diameter may be used and also of shorter length, provided the leg on the spring be made correspondingly longer. My students have found this piece of apparatus entirely satisfactory.

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## SPECIAL ARTICLES

### DIAGRAMS RELATIVE TO HAMILTON'S CANONICAL EQUATIONS

HAMILTON'S equations are so extensively appealed to in modern physics, that the following diagrams which contain considerable information, may be found useful. The masterly treatment given by Sommerfeld has been followed.

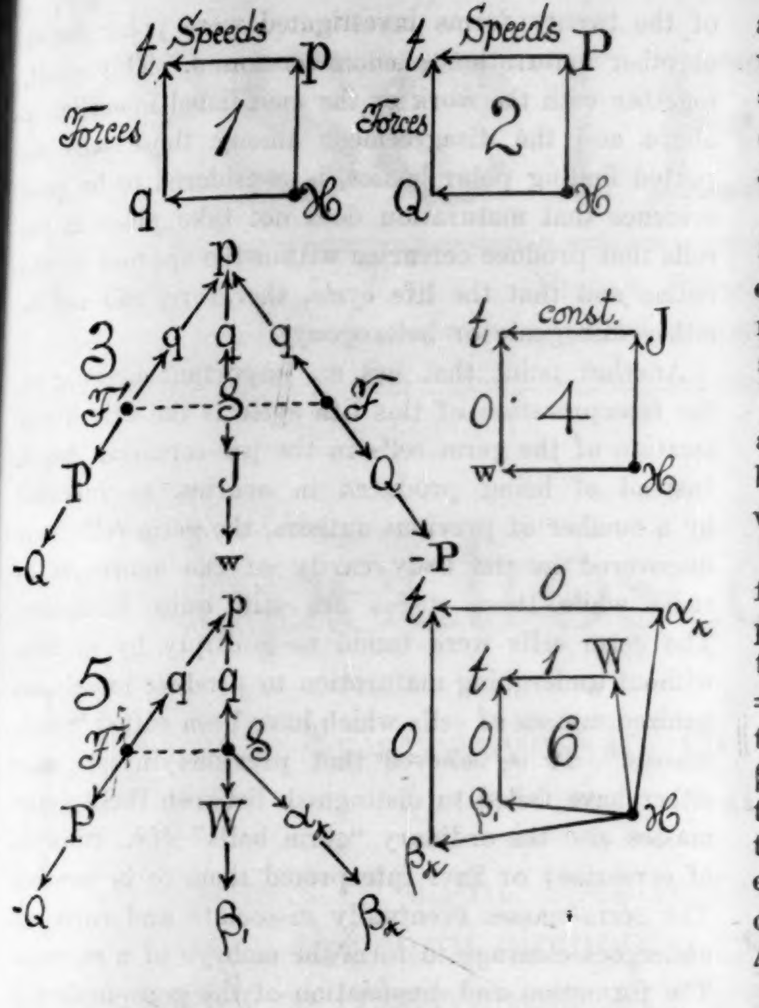
1. In figure 1, the arrows denote differentiations of the total energy $H$, either partial relative to the individual $q_k$, $p_k$, variables, or partial gradients.[1] Differentiations along parallel lines are equal and if the direction is up or to the right both are positive; otherwise one of them is negative. Thus the diagram is to be read

$$\partial H/\partial p_k = \partial q_k/\partial t \text{ or } \nabla_p H = \dot{\mathrm{q}} \;\ldots\ldots\; \text{(speeds)}$$

and

$$\partial H/\partial q_k = -\partial p_k/\partial t \text{ or } \Delta_q H = -\dot{\mathrm{p}} \;\ldots\ldots\; \text{(forces)}$$

[1] Vectors are given in roman, scalars in italics.




We have additionally $\partial T/\partial \dot{q}_k = p_k$ or $\nabla_{\dot{q}} T = p$, $T$ being the kinetic energy. One notes that diagonally opposite corners of figure 1 are essentially scalars and vectors, respectively, and the variables in $H$ are indicated by the diagram.

2. Point transformations, where $Q_k = f_k(q_1 \cdots q_n)$, follow the same rules as given in figure 2. Thus $\nabla_P H = \dot{Q}$; $\nabla_Q H = -\dot{P}$; $P = \nabla_{\dot{Q}} T$ with the variables in $H$ indicated as before.

3. A similar diagram is available to show the conditions under which canonical or contact transformations are admissible. In figure 3, $F$ is a qQ function such that the canonical conjugates are $\nabla_q F = p$ and $\nabla_P F = -P$; whereas $F'$ is a qP function, the conjugates appearing as $\nabla_q F' = p$ and $\nabla_P F' = -Q$. Thus the diagram shows the variables in $F$ and $F'$, but both may also contain time, $t$, explicitly.

With the new Q and P so defined, the diagram figure 2 is again at hand for use with the understanding that $H + \partial F/\partial t$ or else $H + \partial F'/\partial t$ are in general to replace $H$, as for instance in the adiabatic and perturbation phenomena.

4. In case of varied action a function corresponding to $F'$ and which turns out to be the characteristic function $S = \int_0^t 2T dt$ may be made free from explicit time. Moreover if cyclic coordinates are in question P and Q may, as shown in Figure 3, be replaced by $J = §p \cdot dq$ and the cyclic variable w. This cyclic integral § is here to be taken in a vector sense (much like a $\nabla$) so that $i_1J_1 + i_2J_2 + \cdots = i_1§p_1dq_1 + i_2§p_2dq_2 + \cdots$ whence generally $J_k = §p_k dq_k$. Moreover $J = §\nabla_q S \cdot dq = \Sigma § i_k (dS/dq_k) dq_k$ is thus the vector sum of the increments of $S$ in cycles of all the $q_1$, $q_2 \cdots$ in q; *i.e.*, $J_k = §(dS/dq_k)dq_k$.

Finally in the present case, figure 2, is replaced by figure 4, where $H$ ($\alpha$J) and J($\alpha W$) are free from explicit time. Thus $\Delta_w H = -\partial J/\partial t = 0$ since by definition $H$ does not contain w, and $\Delta_J H = \partial w/\partial t$ is constant or $w_k = \nu_k t + w_0$.

If the system varies adiabatically conformably with a slowly changing parameter $a$, $H$ is to be replaced by $H + \phi da/dt$ where $H$ and $\phi$ contain the same variables. Hence $\nabla_w H = -\dot{a}\Delta_w \phi = \partial J/\partial t$.

5. Jacobi's transformations start with the same time free characteristic function $S(q_1 \cdots q_n \alpha_1 \cdots \alpha_n)$ supposedly integrated, and the partial differential equation $H(q_1 \cdots q_n \partial S/\partial q_1 \cdots \partial S/\partial q_n \alpha_1 \cdots \alpha_n) = W = H(q_1 \cdots q_n\ \beta_1 \cdots \beta_n\ \alpha_1 \cdots \alpha_n)$ integrated, but they then vary the constants, *i.e.*, treat the parameters $\alpha$, $\beta$, as variables However, as $\alpha_1$, the last of the arbitrary constants (therefore additive and vanishing in the differentiations) is to be replaced by the time free energy $W$, the condition for contact transformations is conveniently forked at S as shown in figure (5), where $\Delta_q S = p$; $\partial S/\partial W = \beta_1$; and $\partial S/\partial \alpha_k = \beta_k$.

Figure 2 is now replaced by the duplicated square distorted for clearness, figure 6, conformably with the forked figure 5. All the differential coefficients of $H$ here are necessarily zero except (since $H = W$), $\partial H/\partial W = \partial \beta_1/\partial t = 1$, whence $\beta_1 = t_1 + t_0$, which is the time specification of the motion. Hence $\beta_k = \partial S/\partial \alpha_k$ = const., since $\partial \beta_k/\partial t = 0$, give the orbital equations in $q_1 \cdots q_n$ with the constants specified, there being thus in all $n$ equations for the $n+1$ variables including $t$.

In case of perturbations, $H$ is replaced by $H + \phi$, expressed as functions of $\alpha$, $\beta$, W, $\phi$ vanishing for the unperturbed motion. Thus, for instance, $\partial \beta_1/\partial t = 1 + \partial \phi/\partial W$; $-\partial \phi/\partial \beta_1 = \partial W/\partial t$.

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## THE GERM CELL CYCLE OF THE DIGENETIC TREMATODES[1]

THE life cycle of the digenetic trematodes has been a subject for both conjecture and investigation by zoologists for more than a century. Metagenesis, paedogenesis, metamorphosis extending over several generations, dissogenie and heterogony have been put forward as explanations on either theoretical or cytological grounds. Since the investigations on the

[1] From the Department of Helminthology, Johns Hopkins University. This work was done in partial fulfilment of the requirements for the degree of doctor of science in the School of Hygiene and Public Health. A full account will be published later.

cytological background of this life cycle have usually been incidental to some other subject and have in every case been based on the study of one or a very few forms, it seemed worthwhile to attack the problem by making a more extended study and one which would be comparative in nature. The cercaria-producing sporocysts or rediae of twenty different forms well distributed through the trematode classification were used in the investigation. From these studies the former theories were tested and some new evidence bearing on the nature of the life cycle was derived.

Metagenesis is no longer seriously considered as a possible explanation of the life history of this group because it implies that the hermaphroditic adult generation alternates with one that reproduces by a purely asexual method such as budding or fission. Likewise paedogenesis can be ruled out because this term, as used in its original sense, applies only to cases where a larva with sexually mature reproductive organs gives rise to functionless adults. The arguments for a metamorphosis extending over several generations[2] were based largely on the structural homology of the various stages. Although such a homology is easily recognized, this theory lacks the necessary cytological basis to establish it as an acceptable explanation of this life cycle. Since both dissogenie and heterogony require that a maturation process takes place in the reproductive cells of the sporocysts or rediae, polar bodies or other maturation phenomena must be found in these pre-cercarial stages before either of these explanations can be accepted.

Reuss,[3] Haswell,[4] Tennent,[5] Cary[6] and Faust [7] have reported finding polar bodies in the reproductive cells of the cercaria-producing sporocysts and rediae, but disagree with one another in regard to the time and manner of their production and the number of polar bodies resulting. Looss,[8] Coe,[9] Rossbach,[10] Dollfus[11] and Mathias[12] have reported searching for polar bodies without finding them. This point was made the principal objective of the present study. In none of the twenty forms investigated were polar bodies or other maturation phenomena found. This result, together with the work of the men listed immediately above and the disagreement among those who reported finding polar bodies, is considered to be good evidence that maturation does not take place in the cells that produce cercariae within the sporocysts and rediae and that the life cycle, therefore, can not be either dissogenie or heterogony.

Another point that has an important bearing on the interpretation of this life cycle is the origin and location of the germ cells in the pre-cercarial stages. Instead of being produced in ovaries, as reported by a number of previous authors, the germ cells were discovered in the body cavity of the sporocyst or redia while these stages are still quite immature. The germ cells were found to multiply by division without undergoing maturation to produce loosely organized masses of cells which have been called "germ-masses." It is believed that previous investigators either have failed to distinguish between these germ-masses and the ordinary "germ balls" (*i.e.*, embryos of cercariae) or have interpreted them to be ovaries. The germ-masses eventually dissociate and each cell undergoes cleavage to form the embryo of a cercaria. The formation and dissociation of the germ-masses is considered to be a typical case of polyembryony. This process provides a means of germinal multiplication which is much needed on account of the plurally parasitic existence of the worm.

For the previous explanations of the trematode life cycle, a substitute hypothesis is offered interpreting the life history as one in which the germinal lineage passes through successive larval stages in which polyembryony features as a mode of germinal multiplication. The activating factor responsible for the unusual sequence of stages in this life history is thought to be a tendency of the cells of the germinal line to undergo precocious cleavage. This factor is operative first in the miracidium whose somatic development to form a typical adult is restrained by the early impetus of germinal multiplication so that it becomes a "mere reproductive sac" after entering its snail host. The germ cells within this miracidium-mother-sporocyst stage undergo a similar process to form mother rediae or sporocysts. The same procedure is repeated as many times as there are intercalary stages, stopping only when the cells of the germinal line have attained sufficient physiological age and morphological differentiation to produce a form (the cercaria) in which the germ cells are normally restrained and in which the somatic elements can therefore go on to develop a true adult.

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OKLAHOMA CITY, OKLA.

[2] Looss, 1892, "Festschrift f. Leuckart," 147–167.

[3] Reuss, 1903, *Zeit. wiss. Zool.*, 74: 458–477.

[4] Haswell, 1903, Proc. Linn. Soc. N. S. Wales, 27: 497–515.

[5] Tennent, 1906, *Quart. Journ. Micr. Sci.*, 49: 99–133.

[6] Cary, 1909, *Zool. Jahrb. Anat.*, 28: 595–659.

[7] Faust, 1917, Ill. Biol. Monogr., 4: 1–120.

[8] *Loc. cit.*

[9] Coe, 1896, *Zool. Jahrb. Anat.*, 9: 561–570.

[10] Rossbach, 1906, *Zeit. wiss. Zool.*, 84: 361–445.

[11] Dollfus, 1919, C. R. Ac. Sci. Paris, 168: 124–127.

[12] Mathias, 1925, Bull. Biol. de la France et de la Belgique, 59: 1–123.